Towards Smart Endoscope:
Data Collection System for Sinus Surgeries

Computer Integrated Surgery II

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Introduction

In this project, I built a intro-operative data collection system that collects various data during sinus surgeries. This system is the foundation towards understanding the manipulation of endoscopes during surgeries and the development of a “smart” endoscope manipulator.

Problem

In the past 30 years, many efforts have been made to automate the manipulation of endoscopes. However, none of them yielded ideal clinical outcomes. The biggest challenge is to make the manipulation as intuitive, and as effortless as possible for surgeons. This requires predicting and controlling the endoscope based on other sensor information. Therefore, to thoroughly understand the hidden rules and signals behind the manipulation of endoscopes, I built an intra-operative data collection system, which captures the movement of the endoscope, the endoscope video, the movement of a suction tool, and the movement of the patient’s head, as well as the gaze information of the surgeon. Analyzing those data together with preoperative CT and statistical data, we are hoping to finally make the endoscopic manipulator ‘smart’.

Solution

Based on previous literature, and feedback from the surgeons, we designed our system to capture the six different types of data listed in Table 1. A data flow diagram is shown in Figure 1.

Data Name	Data Type	Data Rate	Accuracy	Hardware	Software
Head Pose	Pose	20HZ	0.8mm/0.7°	Head Fixture, 6 DOF Reference, Aurora	sawNDItracker
Suction/Pointer Pose	Pose	20HZ	0.8mm/0.7°	Suction Tool, 6 DOF Cable Tool, Aurora	sawNDItracker
Endoscope Pose	Pose	20HZ	0.8mm/0.7°	Endoscope Adapter, 6 DOF Reference, Aurora	sawNDItracker
Fiducial Position	Pose	20Hz	0.8mm/0.7°	Standard Probe, 6 DOF Probe, Aurora	sawNDItracker
Endoscope Video	RGB Video	30HZ	N/A	FLIR Grasshopper3 HD Camera	Point Grey Driver
Gaze	Gaze	30HZ	N/A	GazePoint	GazePoint API
Comment: all data is logged using rosbag. Gaze information is collected on a Windows computer and then transmitted to and logged on Linux.					

Table 1: Summary of the data system

There are mainly three components of this project: Hardware, Software, and Experimental Design. I contributed to the majority of Hardware and Experimental Design, and partially to Software.

First off, we selected and acquired Aurora EM Tracking System and GazePoint GP3 Eye Tracker based on their specs and requirement of our purposes. Then, in order to attach sensor to surgical tools, I designed and manufactured custom tool adapters, which include the adapter for the endoscope, the adapter for the head reference, and a suction tool phantom. There are number of factors that were taken into account during the designing: ergonomics, metal interference, manufacturability, and reusability. Figure 2, 3, and 4 show the final design for each adapter. Finally, after acquiring all needed hardware components, I also integrated them into a mobile platform.

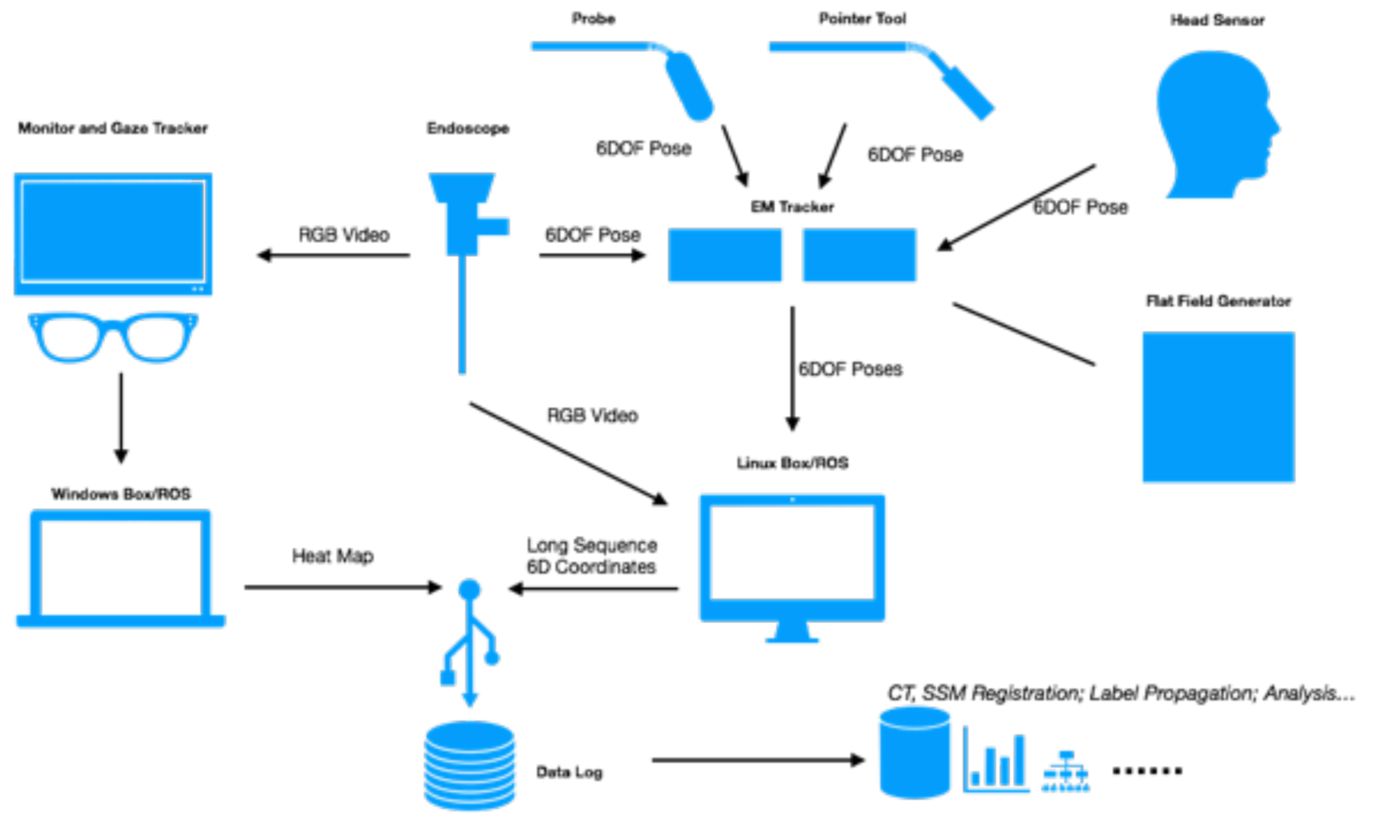

Figure 1: The data flow diagram of the system

On the other hand, I acquired the drivers for each subsystem on ROS, and integrated them into one launch file.

At the same time, I also designed a detailed workflow including the preparation of the cadaver head, the setup of the system, the post-processing of the cadaver head, and the clean up of the surgical tools.

Figure. 2, 3 & 4: Pictures of the final design of (from left to right): the suction tool, the head reference adapter, the endoscope adapter.

Results

The hardware and software part of the system is fully implemented and tested to be functional. Now we are able to collect time stamped data for the normal duration of a sinus surgery. The workflow is completed and submitted for revision.

Future Work

First, I will finish the documentation of the user manual that I’m currently working on. This project will be a part of my Master Thesis. Over the summer, I plan to start collecting data for at least four cadaver experiments. Meanwhile, I will also be finishing the post-processing software, and some calibration and registration algorithms to enable further analysis of the data.

Lessons Learned

- Planning for the unknowns is crucial.
- Doing physical experiment is difficult.
- Even the minutest detail can be significant if ignored.
- It’s very very hard to attend Dr. Ishii’s cases.

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